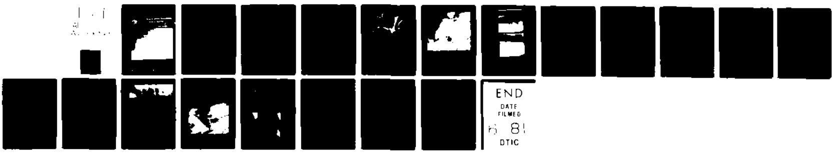
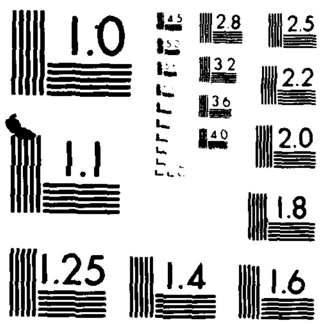
AD-A099 797 NAVAL OCEAN RESEARCH AND DEVELOPMENT ACTIVITY NSTL S--ETC F/G 8/10
REMOTE SENSING OCEANOGRAPHY: A SYNOPTIC APPROACH.(U)
MAR 81 P E LA VIOLETTE
UNCLASSIFIED NORDA-TN-100 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

NORDA Technical Note 100

LEVEL II

(12)

Naval Ocean Research
and Development Activity
NSTL Station, Mississippi 39529

Remote Sensing Oceanography: A Synoptic Approach

Paul E. La Violette

Oceanography Division
Ocean Science and Technology Laboratory

MARCH 1981

ABSTRACT

In order to understand complex, rapidly changing regions of the ocean, synoptic survey methods of study are needed. This presentation outlines one method that utilizes a tight integration of satellite infrared imagery with remote sensors aboard aircraft and standard ship data collection. To demonstrate how the method could be used, a case study is presented of a satellite/aircraft ocean survey taken in May 1979 as part of the Grand Banks Experiment off the coast of Newfoundland. The presentation describes the preparations for the survey and the actual survey, and shows a portion of the post-survey analysis of the data. The case description contains remarks on aspects of the survey applicable to synoptic oceanographic studies in general.

INTRODUCTION

Our understanding of the oceans today is the result of the analyses of vast amounts of data collected from all of the oceans, over many years and throughout all seasons. While our knowledge has advanced considerably, many dynamically complex ocean regions defy standard methods of examination. Yet, these regions, by their very dynamic nature, are critical to a further understanding of the transfer of energy within the oceans.

When an oceanographer initiates an oceanographic survey, he normally positions the track of his research vessel in a systematic manner hoping that the grid pattern thus established will result in a successful survey. In most ocean areas, this method is the best to apply. However, in a region of constant complex movement, this method of ship placement could result in the ship track being tens or even a hundred kilometers offset from the location which could furnish the most oceanographic information.

In addition, as the survey proceeds, the investigator often finds that the ocean feature he is trying to measure is undergoing critical movement as the survey vessel proceeds from one ocean station to the next. Thus, a straight-forward analysis of the station-to-station data without a proper correction for water movement can easily result in a confused, or even worse, erroneous analysis. One method that would aid in understanding the physical processes taking place in such areas would be to conduct surveys whose method of study is based on a synopticity. This report is presented to show how such a survey can be made.

THE SYNOPTIC SURVEY

The key data-collecting elements to the synoptic survey are satellites working in conjunction with surface platforms such as ships and/or aircraft. Infrared data from the satellite(s) would be used to provide continuous, broad coverage of the area's surface thermal features before, during, and after the survey. Remote sensing instruments aboard the aircraft would be used to provide regional coverage at the start of the survey to adjunct the satellite data; the ship/aircraft would then be used to examine in detail critical small-scale features found in the satellite and aircraft regional explorations.

The key element here is the satellite's ability to provide essentially instantaneous regional coverage. This coverage allows specific ocean surface thermal features to be identified and monitored prior to the aircraft and/or ship surveys. An investigator, therefore, with a good understanding of the relationship of a region's surface thermal features with its subsurface dynamic structure could then plan, position, and move the survey ships and aircraft to obtain the most oceanographic information. It must be emphasized that this understanding is critical to the successful use of the satellite data.

An example of such a survey occurred in the waters southeast of Newfoundland in May 1979. Portions of the survey are presented here to demonstrate a case study of the synoptic method described above. Although the presentation is of a particular survey seeking specific results, many aspects of the study are universally applicable to the synoptic survey method.

PRE-SURVEY PREPARATION

Historical aircraft and ship data indicate that the region off Newfoundland, southeast of the Grand Banks, is the confluence of the Gulf Stream, North Atlantic and Slope Waters. On the Grand Banks, the cold, generally southward-moving waters

of the Labrador Current form a dynamic buttress to these warmer, northward-moving waters. The interface of these water masses composes the Labrador Front, a complex pattern of meanders, extrusions and eddies which, in the historical data, seems to generate confusing patterns that change position and strength from season to season and from year to year (Worthington, 1962, 1976; Mann, 1967, 1972; and Clark, et al., 1980).

In 1978, the Naval Ocean Research and Development Activity (NORDA) was the lead agency in the Grand Banks Experiment, a joint U.S.-Canadian ocean investigation. (The rationale for the experiment is explained in detail in La Violette, et al., 1980.) In preparation for the Grand Banks Experiment, four years of satellite infrared imagery were examined. These showed that the confusing patterns were actually cold-water extrusions which were constantly being extended from the Labrador Front. These extrusions always originated from nodal points over specific bathymetric structures. One of the most prominent of these is the Newfoundland Ridge. A schematic diagram of the frontal patterns is shown in Figure 1.

In June 1978, a combined ship/aircraft survey showed that the cold-water feature over the Newfoundland Ridge was not just shallow phenomena, but the surface manifestation of a cold, southeastward-moving extrusion that extended deeper than 1500 meters. The June 1978 data showed the feature was a major ocean structure which appeared to be involved in large exchanges of energy with the warmer waters south and east of the Labrador Front. Based on the results of the June 1978 surveys, a satellite/aircraft/ship survey was planned for May 1979. One of the main purposes of this survey was to intensely examine the frontal features of the Newfoundland Ridge extrusion during a time that it was actively extended from the main Labrador Front. Another year of satellite infrared imagery of the study region was collected and monitored. These imagery indicated that cold extrusions continued to occur during the year. Using this information and the analysis of the previous year's survey, plans were prepared for the May 1979 survey.

THE MAY 1979 SURVEY

During the period of the 1979 survey (8 through 20 May), enhanced TIROS-N and GOES-1 satellite imagery were provided to the oceanographic team in the field. The aerial surveys described here were directed completely by these real-time data. A good description of TIROS-N and its sensors can be found in Schwalb (1978) and Hussey (1979). GOES-1 is best described in Corbell, et al., (1978). The enhanced TIROS-N and GOES-1 data for 15 May 1979, shown in Figures 2 ane 3, are good examples of the imagery used in the May survey. Although of cruder resolution, the GOES-1 imagery were helpful in geographically positioning the sharper details shown in the TIROS-N imagery. In addition, the half-hour period between GOES-1 images allowed comparatively continuous monitoring. During these times when the twice-daily TIROS-N imagery were cloud covered, the half-hourly GOES-1 imagery provided information during those periods when cloud movement allowed portions of the regional thermal gradients to be seen. As the imagery show, the cold-water extrusion over the Newfoundland Ridge was extremely active and well-extended during the survey.

In preparation for the intensive ship/aircraft operation, a regional survey was conducted over the Newfoundland Ridge area on 9 and 10 May by the aircraft using remote sensing instruments. The resulting field analyses of surface temperatures and vertical temperatures resulting from these instruments are shown in Figure 4. These temperatures show that the extrusion contained surface water colder than 9°C and extended at least to 350 meters. An interesting feature of the flight was the use of the aircraft Inertial Navigation System to precisely position the location of thermal fronts during periods when the PRT was ineffective due to low clouds and fog (Fig. 5).

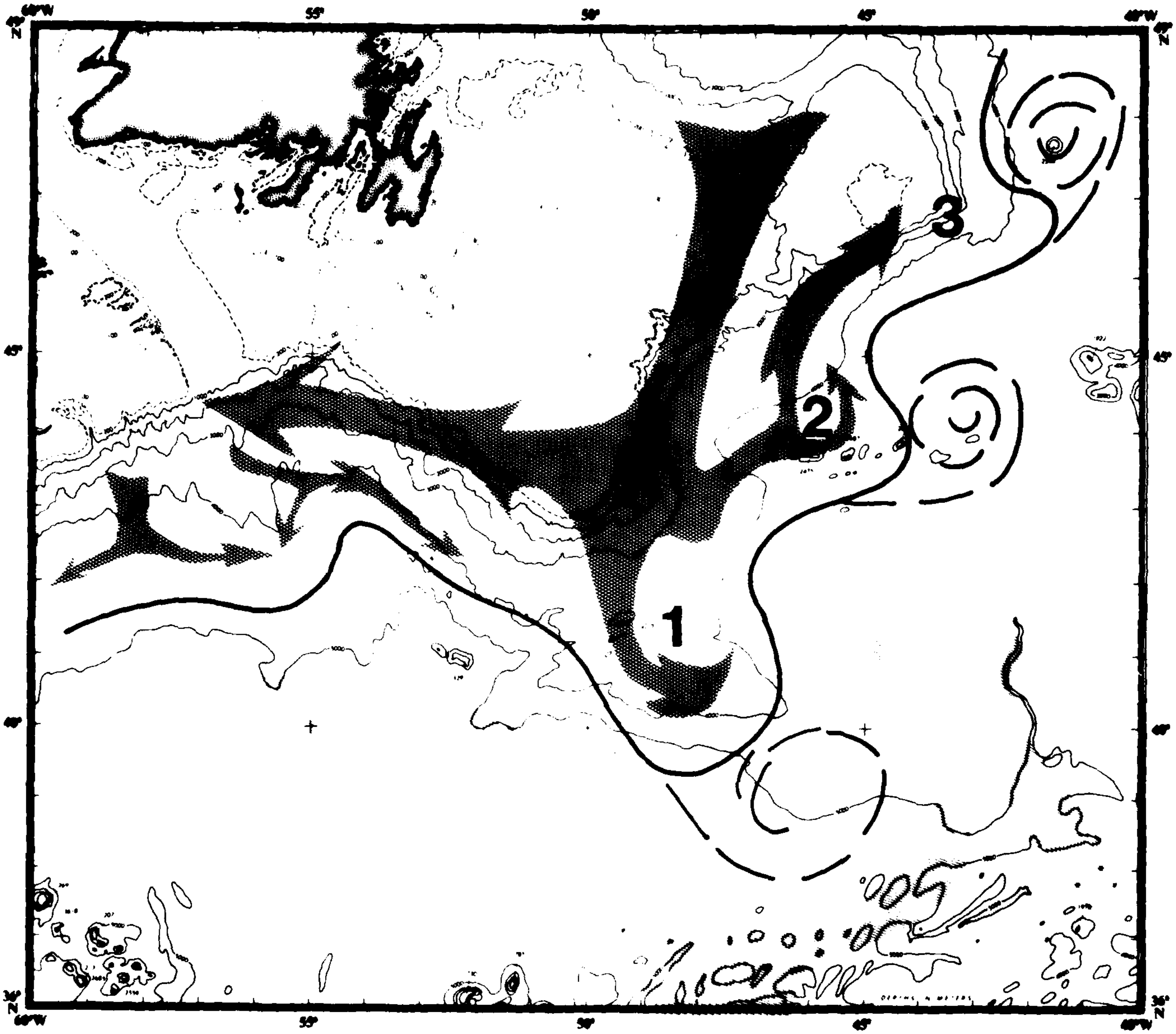


FIGURE 1. The general area of the Grand Banks Experiment. Newfoundland is the land mass in the northwest corner of the chart. The thin lines are bathymetry contours. The schematic drawing overlaying the contours is a general view of the major ocean features as seen in the satellite imagery. The heavy black line represents the Labrador front, and the dark, shaded arrows represent the gross direction of the flow of the Labrador water. The numbers represent the nodal positions from which cold water extrusions were found in the imagery: 1, the Newfoundland Ridge; 2, the Newfoundland Seamounts; and 3, the Flemish Cap. The dark dashed lines were the farthest extensions of these extrusions seen during a given year; in this instance, 1978. The lighter-shaded arrows represent the direction of the Gulf Stream and North Atlantic current.

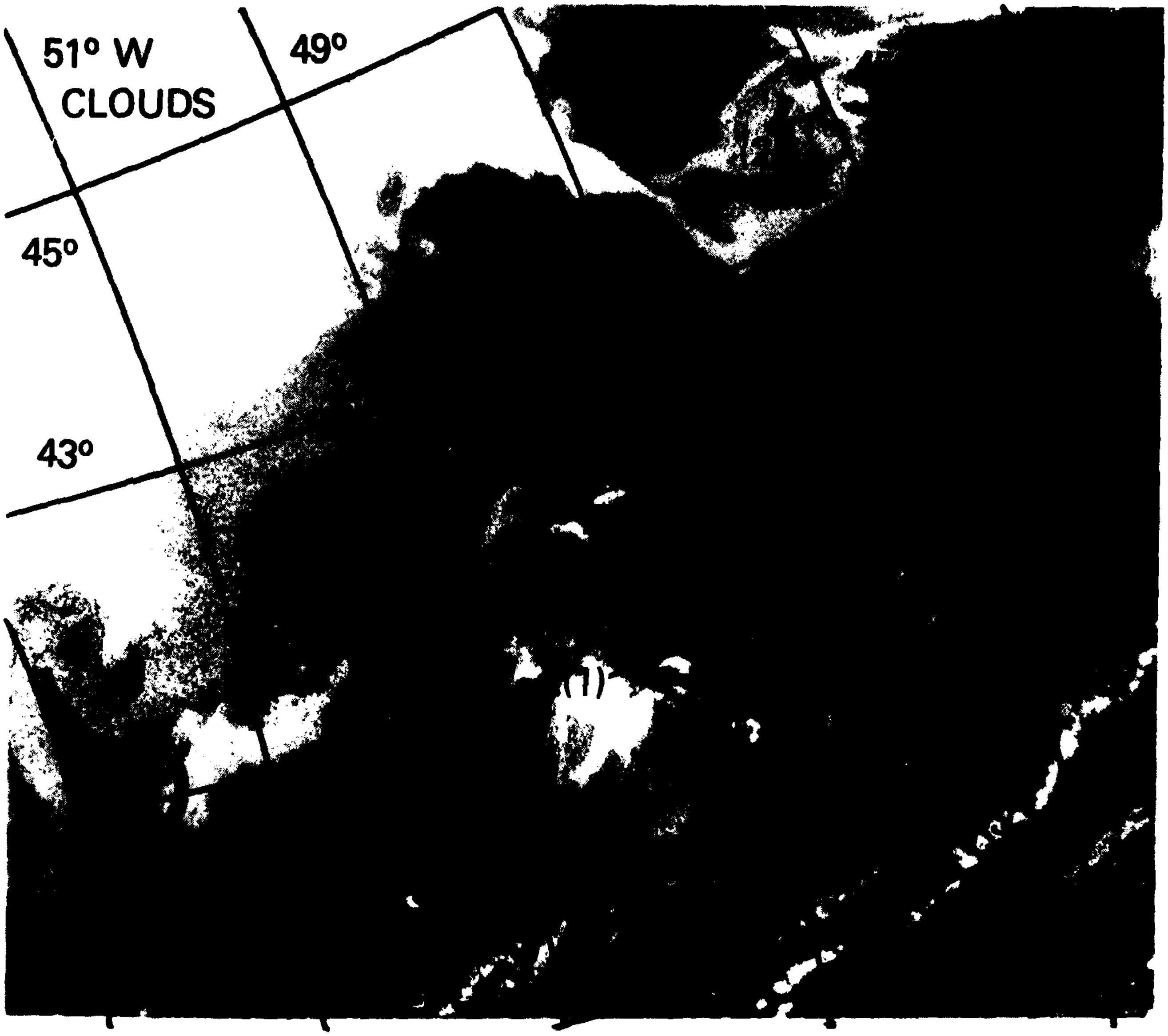


FIGURE 2. TIROS-N infrared imagery for 15 June collected by the satellite receiving station at Shoe Cove. This image and others of equal quality were collected each day during the early morning hours and delivered to the scientific team at St. John's prior to 0630 local. This image has been enhanced to emphasize oceanographic details. The image is not a photograph in the normal sense of the word but is a picture of the earth's thermal radiation. The marked areas are clouds. The rest of the picture shows the ocean, with the light portion being the coldest water and the darkest representing the warmest water. The regions marked 1 and 2 correspond to the Newfoundland Ridge and Newfoundland Sea Mount. (See Figure 1).

A continuing analysis of these images, plus the satellite images from Toronto (Figure 3) and phone conversations with personnel at the NORDA satellite computer facility at Bay St. Louis, Mississippi, resulted in extremely good working knowledge of the weather and ocean frontal conditions in the operating area. All flights were made based on these data.

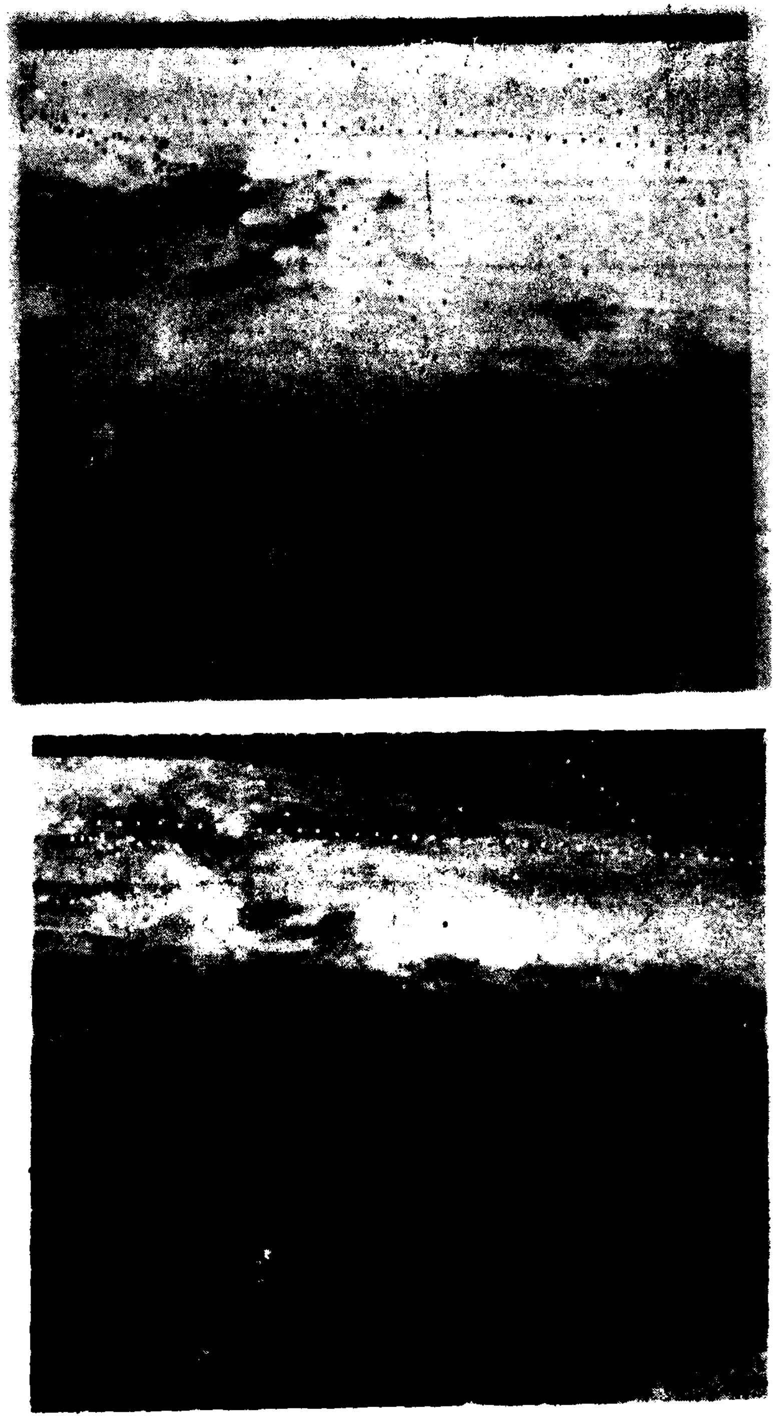
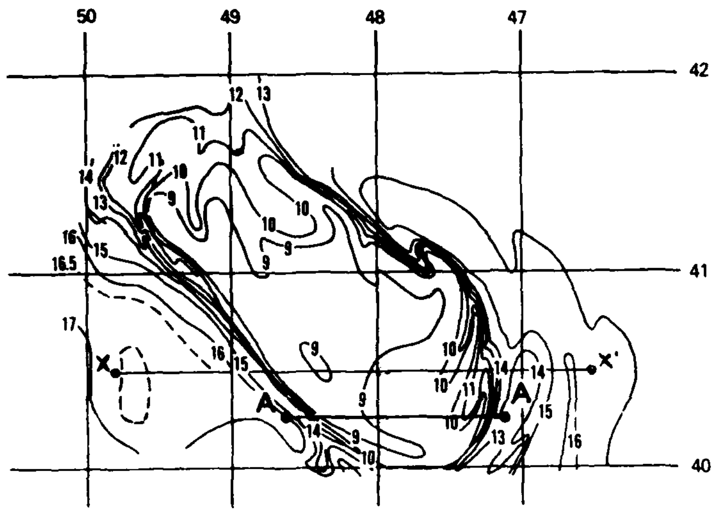


FIGURE 3. Examples of the GOES VISSR imagery provided each day by the Canadian Atmospheric Environmental Service (AES). These samples are for the same day 15 May as Figure 2. Approximately 4 sets of infrared normal, enhanced, and visible images for the periods 1330 hours to 1830 hours GMT for each day were sent as a package via EXPEDAIR arriving at St. John's at midnight of the same day of reception. The latitude and longitude gridding of the imagery, plus the several daily views, allowed accurate positioning of the frontal structure under the constantly shifting cloud cover.

(A) ANALYSIS OF 9 AND 10 MAY, 1979 PRT DATA (°C)



(B) ANALYSIS OF 9 AND 10 MAY, 1979 AXBT DATA (°C)

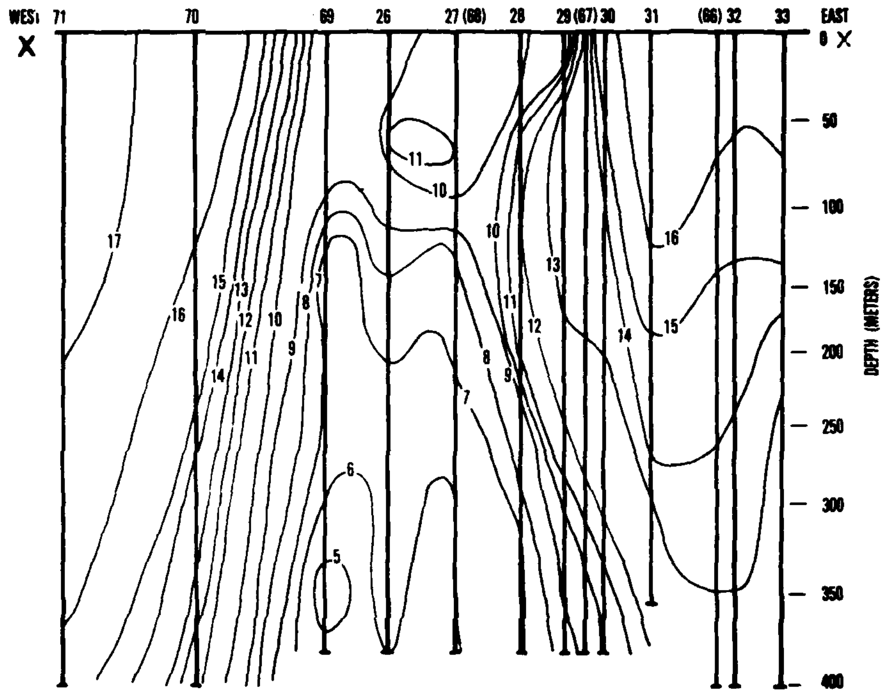


FIGURE 4. Analyses of Precision Radiation Temperature (PRT) and Airborne Expendable Bathythermograph (AXBT) data for the regional survey conducted on 9 and 10 May 1979. In the PRT analysis (A), the X-X' line refers to the location of the AXBT cross section (B) (the A-A' line refers to the INS accelerometer and PRT traces presented in Figure 5). During these two exploratory flights, subsurface thermal samplings were made using AXBT's every 10 miles using a total of 110 AXBT's. Thus, in addition to the detailed surface temperature chart derived from PRT data, subsurface charts were analyzed for levels down to 350 meters using AXBT data. The AXBT cross section analysis presented in (B) is very simplistic. It has not been coordinated with the surface PRT data nor with the AXBT dropped north and south of the line X-X'. The two analyses were made in the field as an aid to operationally controlling the ongoing survey.

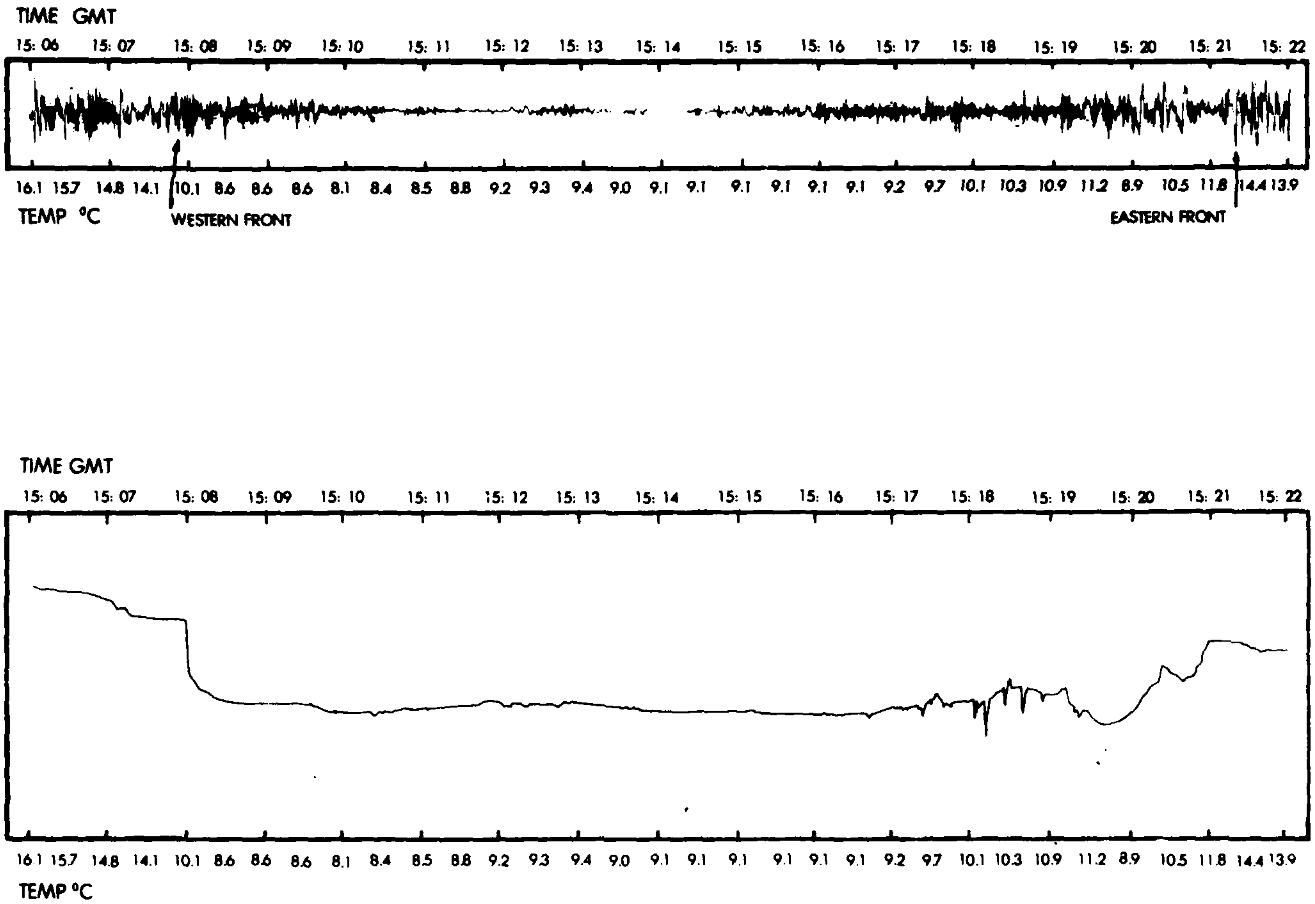


FIGURE 5. An example of the variations in vertical atmospheric turbulence across the western (A) and eastern (A') thermal fronts. A pengraph attached to the vertical accelerometer of the aircraft Inertial Navigation System showed the vertical movement of the aircraft as it flew across the frontal structure at an altitude of 300 meters on 10 May (see line A-A' of Figure 4). The western front having the sharpest thermal gradient of the two fronts, showed the quickest atmospheric response. The horizontal wind field, as measured by the aircraft's drift for the same altitude and time, showed no appreciable deviation. This lack of horizontal variability was found in later flights, even when the aircraft flew as low as 70 meters above the water.

This example is only one of a number of similar INS graphs made during the flights. Of particular interest to this paper is that during periods when the aircraft was flying through obscuring low clouds or fog with the PRT inactive, the INS graphs indicated changes in vertical turbulence which were shown to be associated with thermal fronts by simultaneous AXBT drops. This method of locating the position of thermal fronts became a standard tool during the survey.

At this time in the survey, poor weather and mechanical problems with the aircraft stopped operations for one week. During this delay period, the TIROS-N and GOES imagery were monitored daily to see if any changes were taking place in the structure of the ridge feature.

Meanwhile, the poor weather had slowed the progress of the ship into the study area. As the weather continued to deteriorate, it became obvious that the ship was not making sufficient headway to allow it to join the survey. The ship operation was therefore cancelled. This event now left the survey completely dependent on the aircraft for "in situ" data. The frontal monitoring by the satellite imagery became even more critical. On 15 May the satellite imagery showed that the structure of the ridge feature had not drastically changed during the one-week delay. Using this information, an intensive aerial survey of one portion of the ridge feature was planned for 16 and 17 May. The discussion which follows will center mainly on the 16 May survey.

The 16 May frontal study was designed to cut a 150 kilometer cross section across the cold tongue of extruded water. Synoptic measurements involving the temperature, currents, and wave spectra of the ocean and temperature, humidity, and pressure variations in the atmosphere were to be made along the section. The results would show an instantaneous view of how physical conditions in the atmosphere and ocean were across the feature.

The actual flight required a complex orchestration. The scenario given to the flight scientists is interesting as it shows how the desire to retain synoptic data orchestrated this fine-scale portion of this satellite/aircraft survey. The scenario is given in Table A and Figure 6 (an alternate scenario was also provided in case unexpected weather or system failure might cause the crew to abort the original plan). The scenario called for multi-level runs to be made at 75, 150, 1500, and 3000 meters in order to collect atmospheric humidity, temperature, and pressure. Aerial photography and infrared scanner data were also to be collected at these levels in order to describe the relationship of the region's wave spectra with thermal features of the front.

Because of the absence of the ship, other data had to be included in the data collection. Interwoven in the climbs and descents of the multi-level runs, transects were planned which involved dropping (and tracking) sonobuoys, dyes, and XBTs.

Note that the sonobuoy drop scenario (Fig. 6) was merely a frame of action. The actual drop positions were completely dependent on the low-level PRT run of transect #2. Upon completion of this run, the aircraft survey team would use the PRT data in combination with the satellite imagery and the ongoing performance of the aircraft to fine tune the actual drops.

If the intricate maneuvers described in the scenarios were to be successful, precise knowledge of three conditions were needed:

1. Where the best place would be in the frontal extrusion to perform the transects.
2. Exactly where this position would be on the day of the flight.
3. A guarantee of clear-sky conditions on the day of the flight.

The first condition was derived from both the 9/10 May survey and the TIROS-N field imagery collected during the one-week delay. The second and third conditions were derived from TIROS-N and GOES-1 data received several hours before flight time.

TABLE A. GENERAL SCENERIO #1 FOR 16 MAY 1979

TRANSECT	ALTITUDE	OPERATION
1	3,000 m	Proceed from St. John's to PTs 1 to 2 to 3 to 4. Use Aircraft Meteorological Sensors, TV and film cameras and infrared scanner.
Change Altitude	3,000 to 25 m	At Pt 4, spiral down from 3,000 to 75 m from 10,000' to 200'. Use Meteorological Sensors as radisonde probe.
2	75 m	Critical run. Proceed from PT 4 to 5. Use Meteorological Sensors and PRT.
Change Altitude	75 m to 300 m	
3	300 m	Proceed from PT 5 to 4. Use Meteorological Sensors and PRT. Drop sonobuoys, dyemarkers, and smoke buoys as described in Drop Scenerio. Use aircraft Meteorological RADAR to precisely pinpoint front for dye and sonobuoys #4 and #12 drops.
Change Altitude	300 to 1,500 m	
4	1,500 m	Proceed from PT 4 to 5 to 4. Use TV and film cameras and infrared scanner.
Change Altitude	1,500 to 150 m	
5	150 m	Proceed from PT 4 to 5. Use theolodite laser and drop XBTs. Proceed from PT 5 to 4. Track sonobuoys.
Change Altitude	150 to 75 to 3,000 m	At PT 4 descend to 75 m then spiral to 3,000 m using Meteorological Sensors.
6	3,000 m	Proceed from PT 4 to 5 to 6. Use TV and Film cameras, infrared scanner and Meteorological Sensors.
Change Altitude	3,000 to 75 to 150 m	At PT 6. Spiral down to 75 m then rise to 150 m and proceed to PT 5.
7	150 m	Proceed from PT 5 to 4. Track sonobuoys.
Change Altitude	150 m to 3,000 m	
8	3,000 m	Proceed from PT 4 to 3 to 2 to 1 then to St. Johns. Use TV and Film cameras, infrared scanner and Meteorological Sensors.

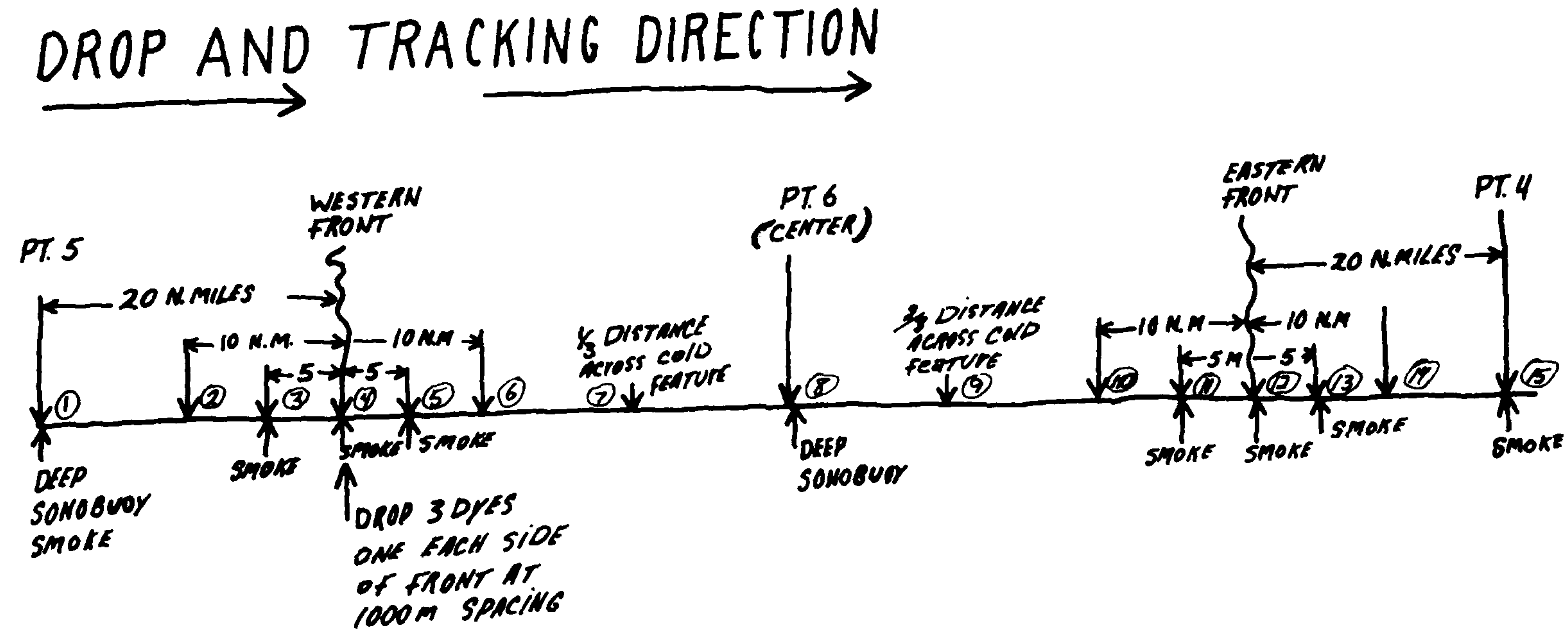


FIGURE 6. SONOBUOY DROP SCENARIO

NOTE: Drop positions were determined from PRT data collected during flight track 2. Exact drop positions on western and eastern fronts were directed by aircraft meteorological radar and checked by PRT. All drops included 18 meter sonobuoys except #1 and #8. This sketch was used by the aircraft scientific crew to make the drops.

The TIROS-N infrared imagery were used to precisely locate the transect position across the front on the day of the flight, while the GOES-1 visible and infrared imagery were used to continuously monitor the weather conditions in the survey areas as well as to produce comparatively coarse views of the front.

During the Grand Banks Experiment, the field satellite data were provided by several sources. The Atmospheric Environment Service of Canada flew enhanced TIROS-N and GOES-1 imagery to the operating site (St. John's, Newfoundland) daily from Toronto. The Shoe Cove satellite direct-readout station, located 40 kilometers from St. John's, provided enhanced TIROS-N imagery, and finally, a phone-patch with photo and conversation transmission capabilities were maintained with the NORDA computer facility in Bay St. Louis, Mississippi. Each of these satellite data sources were necessary to act as a back-up should one or both of the other sources fail. During the two weeks of the survey, failures due to weather and system break-down did occur.

While the means to receive satellite services described above may seem elaborate, similar sources of such data are available to most field surveys. Most weather services have satellite direct-readout displays, and the deployment of one member of an oceanographic team to monitor the imagery and report by phone or radio to the field party would provide at least the minimum of the requirements detailed in this paper. In addition, small field satellite receivers are commercially available. The use of such a system in the operation of an ocean survey is discussed in La Violette, et al., 1975.

The 16 May intensive aircraft survey of 16 May went as planned. Based on its success, another survey was flown on 17 May in the same region, equally complex, but involving different remote sensing instrumentation. Samples of the results of the 16 May sonobuoy and dye tracking are shown in Figures 7 and 8. Since this report has the purpose of showing a method rather than results, the full analysis of the 16 May survey is not presented here. The reader is invited to read La Violette, 1981, for further results on the Grand Banks Experiment.

In the post-survey analysis, the data from the surface platforms were merged with mercator registration of TIROS-N imagery to show the relationship of the data collected with the total frontal extrusion (Fig. 9, the methodology of the computer enhancement, registration, and calibration of these data, is decribed in Holyer, La Violette and Clark, 1980). In addition, in the post-survey analyses the satellite data were used to describe short-term changes in surface features which, because of time restrictions, could not be examined by the aircraft. An example of one such change involving the Newfoundland Ridge is shown in Figure 10.

CONCLUSIONS

The successful study of complex ocean structure within the first 1000 meters of the ocean requires that synoptic methods be used. The most successful of these methods requires a combination of remote sensor data from both aircraft and satellites. This paper shows a survey utilizing such sensors to collect critical ocean data that would be impossible to collect in any other fashion. Although the presentation shows a specific survey conducted over the Grand Banks, the basic principles shown are applicable to other ocean regions. The surface platforms used in the intensive portion of a survey of this nature will, of course, change according to the needs of the study. However, the basic idea of the pre-survey broad regional reconnaissance by satellite and aircraft is a vital prerequisite to initiate the intensive phase of the survey. When applicable, this combination of early reconnaissance, intensive study and post-survey monitoring will insure a proper understanding of the physical events taking place in complex ocean regions.

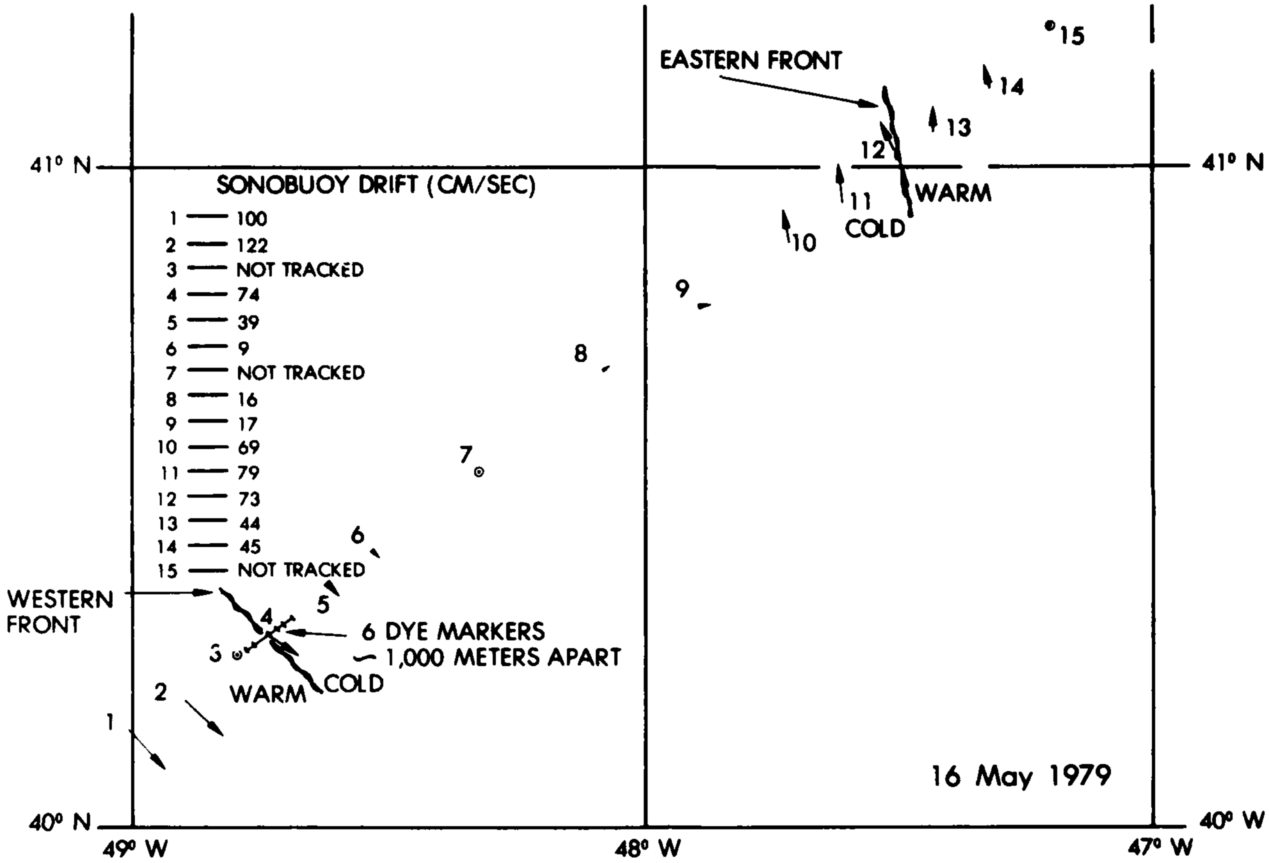


FIGURE 7. Drift determination across the main frontal feature using sonobuoys. On 16 May 1979, 19 sonobuoys were dropped from the aircraft to form a right angle cut across the western and eastern fronts of the structure shown in Figure 2. Although some movement of the feature occurred between 9 and 10 May and the time of these drops, the feature remained grossly the same. Sonobuoys at positions 2, 3, 4, 5, 6, 10, 11, 12, 13, and 14 were dropped at 9 kilometer spacing. Normally, the sonobuoy receivers were set for 18 meters. At positions 1 and 8, however, additional buoys were dropped with receivers set for depths of 90 and 300 meters so that the gross acoustical variation across the western front could be determined. At the end of approximately two hours and twenty minutes, the lines were reflown and the buoys tracked, and their positions marked using the aircraft INS. Because the path of the aircraft during the dropping of the buoys and their tracking was in the same direction, the drift time for the buoys was fairly uniform--the total variation between the times of drop and track at positions 1 and 15 was less than five seconds.

In addition to the sonobuoys, six dye markers were dropped between positions 3 and 5 with the third dye marker and the position 4 sonobuoy being dropped together exactly on the western front. A further description of the dye drops accompanies Figure 8.

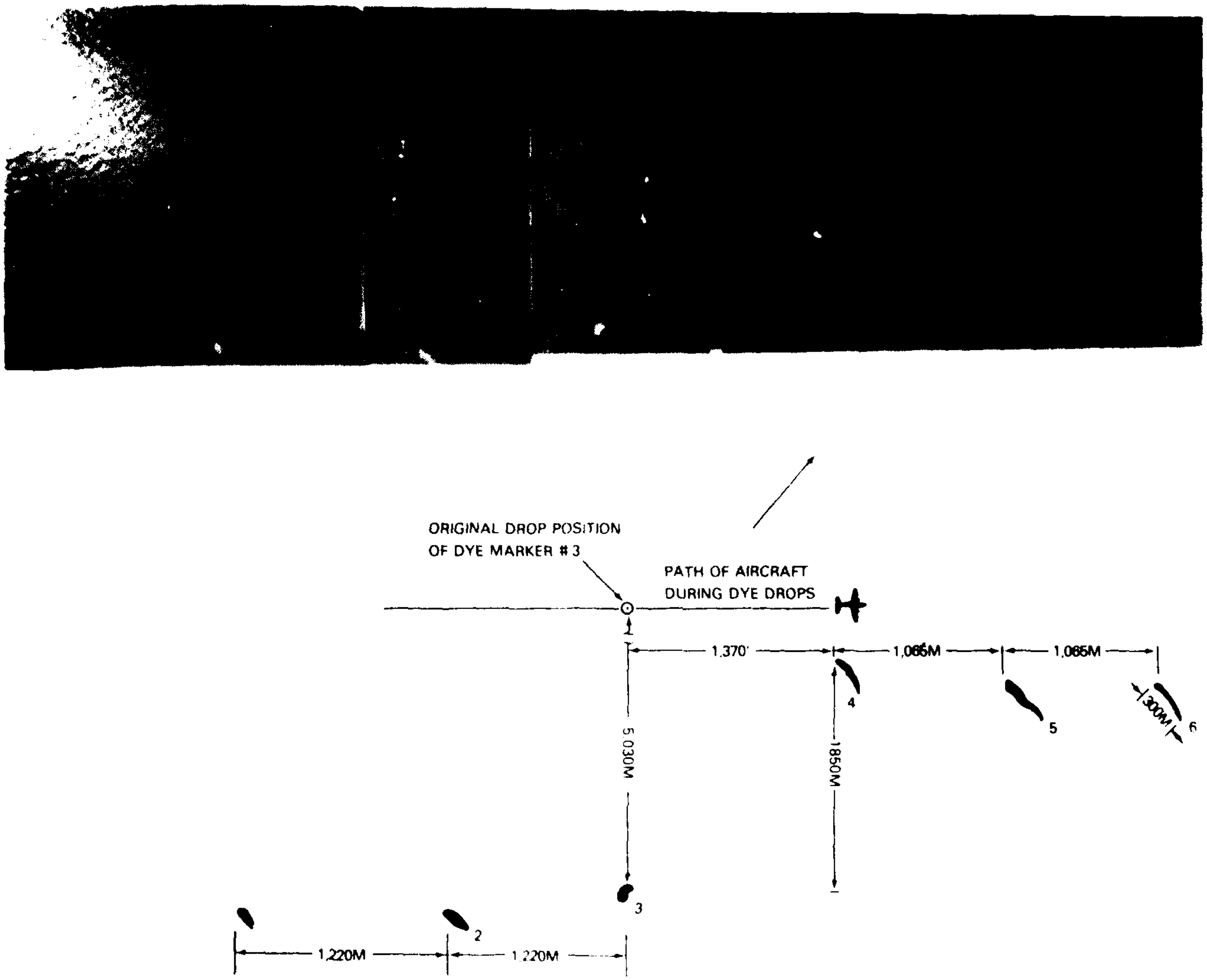


FIGURE 8. Aerial photographs of dye markers showing the shear present at the western frontal zone. Six dye markers were dropped in a straight line by the aircraft as part of the sonobuoy drop of 16 May (Figure 7). The positions shown in the photo mosaic are their drift after one hour and ten minutes. Although not discernible in the nadir-oriented photographs, the front, laying almost exactly on dye marker #3 and at right angles to the plane's flight, was plainly visible from the aircraft. The front was also visible as a sharp change in sea clutter on the aircraft meteorological search radar and presented a sharp shift on the PRT trace (see Figure 4 for a sample of the PRT gradient present over the western front).

One interesting aspect of the photographs is the small drift of the dyes on the cold side of the front as compared to the warm side. An examination of the movement of the sonobuoys in Figure 7 would indicate a gradual change in current speed as the aircraft approached the center of the frontal structure. The mosaic presented in this figure suggests an alternative view; that the apparent gradual change in current velocity may be a result of the wide spacing of the sonobuoys and that the changes may instead be quite sharp, with zones of fairly uniform velocities lying in between the regions of sharp change.

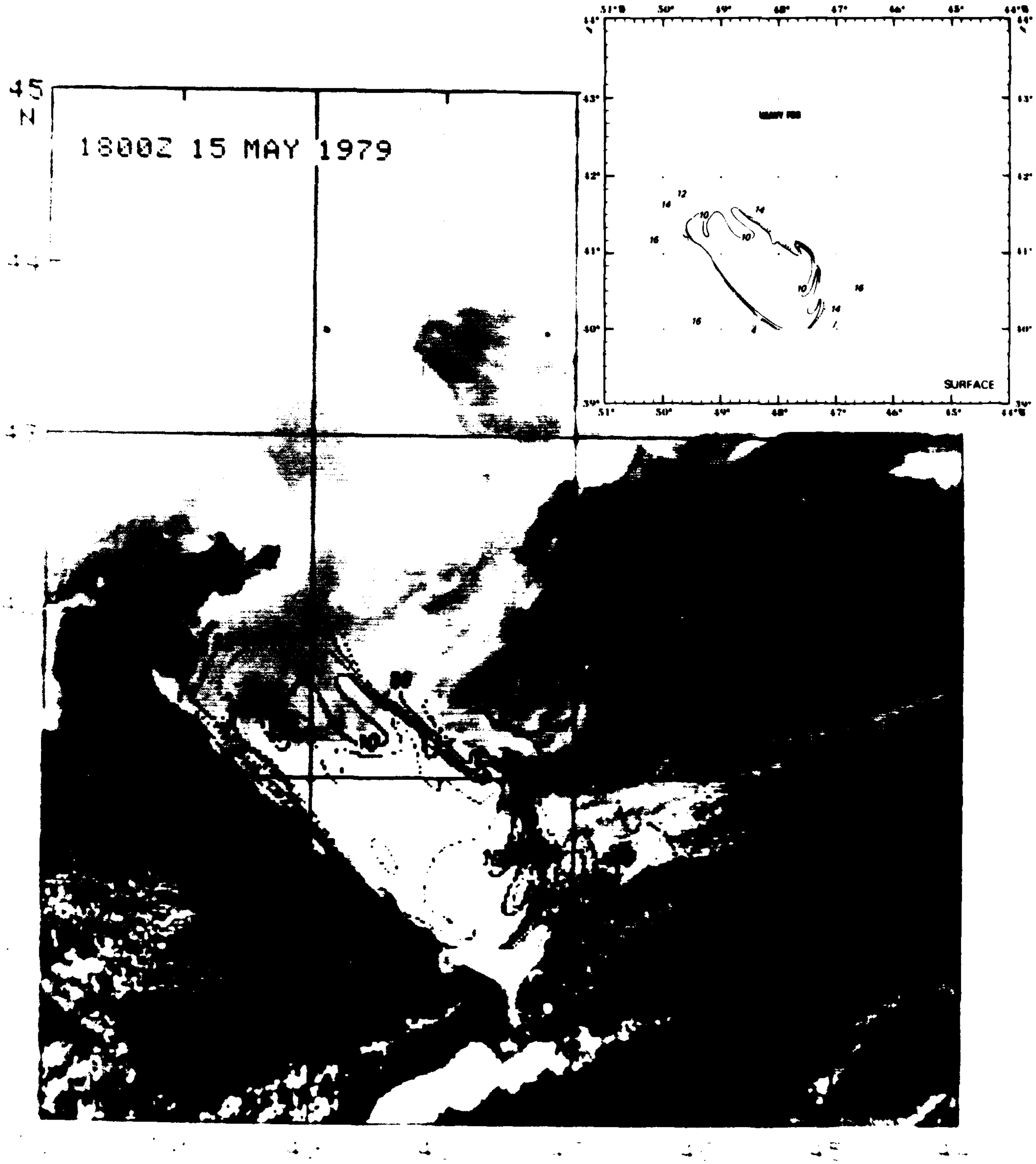


FIGURE 9. The PRT-5 sea surface temperature analysis for 9/10 May inset on the 15 May registered satellite infrared image.

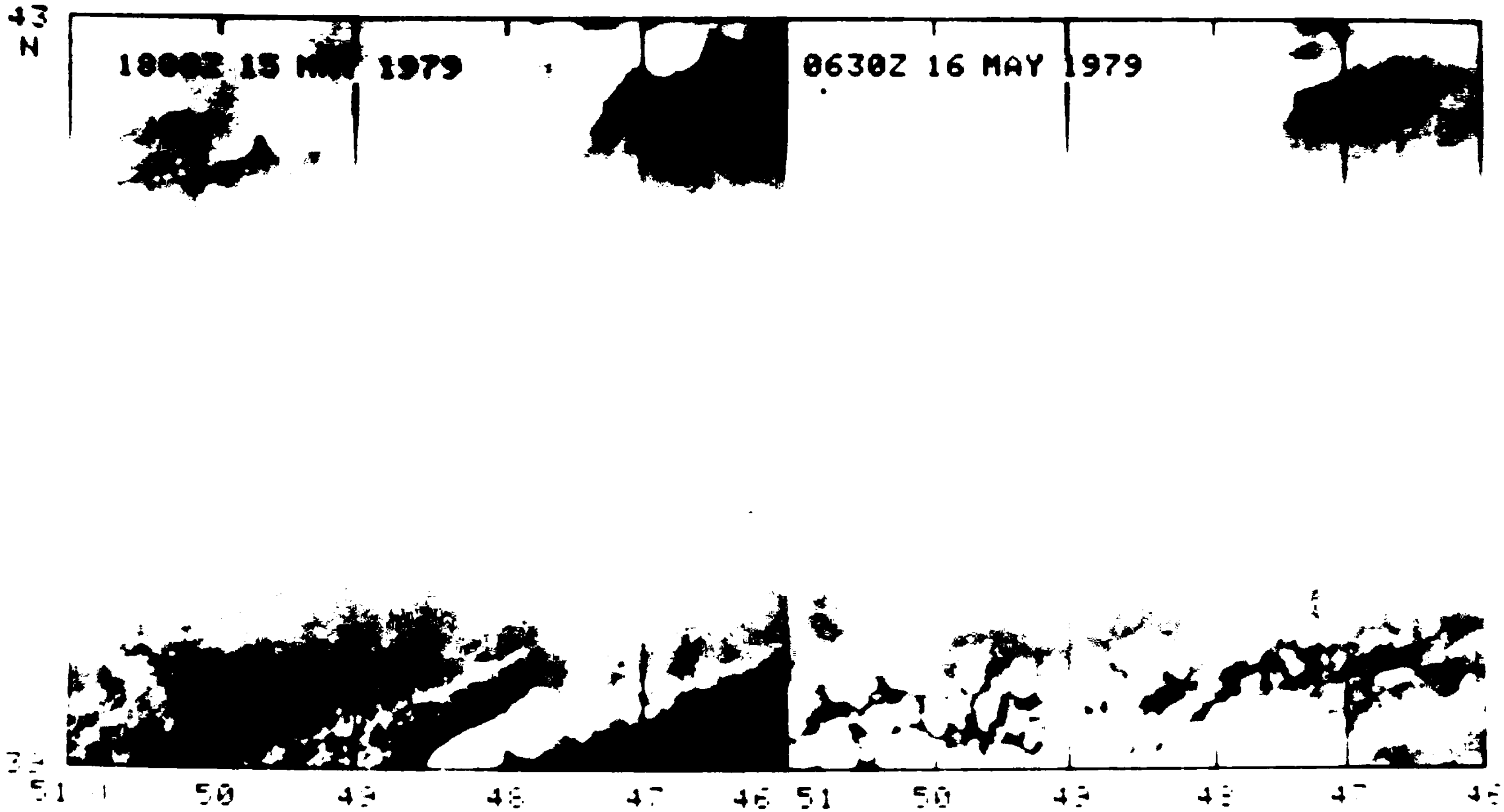


FIGURE 10. An example of the frontal wave movement shown by the satellite imagery. During the approximately 12 hour period between the two passes, the frontal waves on the western side of the cold feature had moved southeasterly at a rate of 65 cm/sec.

REFERENCES

Clarke, R.A., R.F. Reininger and A. Warren (1980). Current System South and East of the Grand Banks of Newfoundland. J. Phys. Oceanogr. 10, 25-65.

Corbell, R. P., C. J. Callahan, and RADM William J. Kotsch (1978). The GOES/SMS User's Guide. NASA Contract NAS 5-20694.

Holyer, R.J., P.E. La Violette, and J.R. Clark (1980). Satellite Oceanographic Research Development and Technology Transfer. Proceedings of the Fourteenth International Symposium on remote sensing of Environment, May, Ann Arbor, Mich (in press).

Hussey, W. J. (1979). The TIROS-N/NOAA Operational Satellite System. National Environmental Satellite Service/NOAA, Washington, DC, May, NOAA Tech. Memo. 95 NESS, 35 pp.

La Violette, P.E. (1981). Variations in the Frontal Structure of the Southeastern Grand Banks. Tech. Report in Press, Naval Ocean Research and Developement Activity, NSTL Station, MS

La Violette, P.E., L. Stuart, Jr. and C. Vermillion (1975). Use of APT Satellite Infrared Data in Oceanographic Survey Operations. EOS, 56., 276-282.

La Violette, P.E., S. Peteherych and N.F.R. Gower (1980). Oceanographic Implications of Features in NOAA Satellite Visible Imagery. Boundry-Layer Meteor., 18, 159-175.

Mann, C.R. (1967). The Termination of the Gulf Stream and the Beginning of the North Atlantic Current. Deep Sea Res., 14, 337-359.

Mann, C.R. (1972). A Review of the Branching of the Gulf Stream System. Proc. R.S.E., 33, 341-349.

Schwalb, A. (1978). The TIROS-N/NOAA A-G Satellite Series. National Environmental Satellite Service, NOAA, Washington, DC, March, NOAA Tech. Memo NESS 95, 75 p.

Worthington, L.V. (1962). Evidence for a Two Gyre Circulation in the North Atlantic. Deep-Sea Res., 9, 57-67.

Worthington, L.V., 1976: On the North Atlantic Circulation. The John Hopkins Oceangro. Stud., 6, 110 p.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

(14) NORDA-TN-100

(9) REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: NORDA Technical Note 100	2. GOVT ACCESSION NO.: AD-A099797
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): (1) Remote Sensing Oceanography: A Synoptic Approach	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): (10) Paul E. La Violette	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Naval Ocean Research & Development Activity, Ocean Science & Technology Laboratory, Code 330, NSTL Station, Mississippi 39529	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: Same	12. REPORT DATE: (11) Mar[redacted]981
	13. NUMBER OF PAGES: 17
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): (12) 24	15. SECURITY CLASS. (of this report): UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

In order to understand complex, rapidly changing regions of the ocean, synoptic survey methods of study are needed. This presentation outlines one method that utilizes a tight integration of satellite infrared imagery with remote sensors aboard aircraft and standard ship data collection. To demonstrate how the method could be used, a case study is presented of a satellite/aircraft ocean survey taken in May 1979 as part of the Grand Banks Experiment off the coast of Newfoundland. The presentation describes the preparations for→ next

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

S/N 0102-LF-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

392773 JU

the survey and the actual survey, and shows a portion of the post-survey analysis of the data. The case description contains remarks on aspects of the survey applicable to synoptic oceanographic studies in general.

DATE

ILME